

**National Exposure Research Laboratory
Research Abstract**

Government Performance Results Act (GPRA) Goal #1
Annual Performance Measure #264

Significant Research Findings:

**Characterization of Emissions from Small, Hand Held, In-Use
2-Cycle Engines****Scientific
Problem and
Policy Issues**

EPA began regulating emissions from small gasoline-powered spark-ignition (SI) engines (e.g., lawn mowers, string trimmers, chainsaws, and leaf blowers) in 1997. Most of these engines are now subject to emission standards; however, many of the small SI engines currently in use are the older, pre-control engines that are not subject to emission standards. Data are needed from these pre-control in-use engines, as well as from the newer emission-controlled engines for estimating their contribution to the emissions inventory for particulate matter (PM), air toxics, and regulated gases.

**Research
Approach**

The EPA's National Exposure Research Laboratory (NERL) characterized emission rates from 18 small, SI, hand-held, in-use, 2-cycle engines from model years 1987 - 2002. These used engines (12 string trimmers and 6 chain saws) were obtained from local consumers, pawn shops, and lawn service vendors. All engines were tested in "as is" condition, with only the minimum maintenance performed in order to get them to run properly on the small engine dynamometer. NERL also tested 5 new 2-cycle 2003 model year engines (3 string trimmers, including one 4-cycle hybrid engine, one chain saw, and one leaf blower) loaned by the Outdoor Power Equipment Industry Association (OPEI) through EPA's Office of Transportation and Air Quality (OTAQ). The engines tested represent a variety of makes, model years, and displacement characteristics, though they may not represent all engines with similar characteristics.

Emissions were measured for total hydrocarbons (THC) plus over 200 individual hydrocarbons; carbon monoxide (CO); oxides of nitrogen (NOx); various air toxics; and fine particulate matter (PM). Fuel consumption was also measured. All engines were tested using two different fuels (summer gasoline and a reformulated gasoline containing 10% ethanol) and two different 2-cycle oils (mineral-based premium low smoke oil and a synthetic-based oil) in a variety of combinations. Special tests were run on several of the OPEI-supplied engines to determine the influence of dynamometer design and fuel composition on emission rates, and to compare emission rate results from two different test procedures. (The duration of the test was extended from 6 minutes to 10 minutes to ensure adequate sample size for chemical analysis.)

**Results and
Impact**

Overall, the older (pre-control) engines emitted significantly more pollutants than did the newer ones. The lowest THC, CO, and fine PM emitters were all newer

(emission-controlled) model engines; however, the highest NO_x emitter was the 2003 model year hybrid 4-stroke engine. Most of the air toxic emissions measured came from unburned fuel and oil passing through the engine, and they closely mirrored the THC emission rate. The 2-stroke oil composition had little or no effect on THC, CO, and NO_x emission levels; however, fine PM emissions were slightly elevated when using the synthetic oil. The reformulated fuel resulted in slightly lower CO emissions but significantly increased aldehyde emissions. The dynamometer design was shown to influence the measurement of engine power output (and subsequent emission results) by up to 13%. Emission rates were about the same for the fuel types tested. Comparison of the two different test procedures (*i.e.*, durations) showed the emissions to be consistent on a per minute basis, even though the small number of engines tested this way showed a lot of variability in emissions from engine to engine.

The results of these emission tests have yielded the highest quality and most recent emissions data on non-road small engines and these data are a key component for updating the mobile source sector of the National Emission Inventory (NEI) developed by EPA's Office of Air and Radiation (OAR). The small non-road emissions data has proven to be important because the current NEI indicates that the non-road small engine source sector is the second largest contributor to mobile source gaseous hazardous air pollutant (HAP) and volatile organic compound (VOC) emissions behind light duty vehicles. The NEI is used by EPA, Regional Planning Organization, States, Local and Tribal organizations, and others to perform modeling analyses in support of policy decisions, exposure and risk assessments, and control strategy development and evaluation.

Research Collaboration and Research Products	This project was conducted by NERL and its on-site contractor, Bevilacqua Knight Inc., at NERL's mobile source research facility located Research Triangle Park, NC, with support from OPEI and EPA's OTAQ. This research is presented in an Internal EPA Report "Characterization of Emissions from Small, Hand-Held, In-use 2-Cycle Engines" by James N. Braddock, William S. Crews and Richard F. Snow, September 2004.
Future Research	NERL's Organic Analysis Laboratory is in the process of analyzing the particulate matter filters for a variety of organic chemicals. Results will be reported in future NERL publications.
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